EML 4551-2

Energy Demand Reduction for FSU's Central Utility Plant

Group members: Edgardo Cordero, Alec Schoengrund, Steven Decker,
Mira Meyers, Keaton Zargham, and Juan Villalobos

Team Introductions

Alec Schoengrund
Mechanical Design Engineer

Keaton Zargham
Data Analyst

Mira Meyers
Quality Control Engineer

Edgardo Cordero
Project Manager

Juan Villalobos
Energy Auditor

Steven Decker
HVAC Engineer

Zargham

Sponsor and Advisor

Engineering Mentor
Cameron Griffith
Solutions Advisor, LEED AP, CEM, CDSM

TRANE

Academic Advisor
Dr. Juan Ordonez, Ph.D.
Professor of Thermodynamic Optimization for Advanced Energy Systems

Zargham

Objective

To research, study, evaluate and propose a project that reduces FSU Facility's Electric Utility bill by reducing peak demand and/or the overall electric consumption to generate a financial payback to FSU.

Zargham

Project Background

- Large scale operations such as Florida State University spend Millions of dollars on utilities each year.

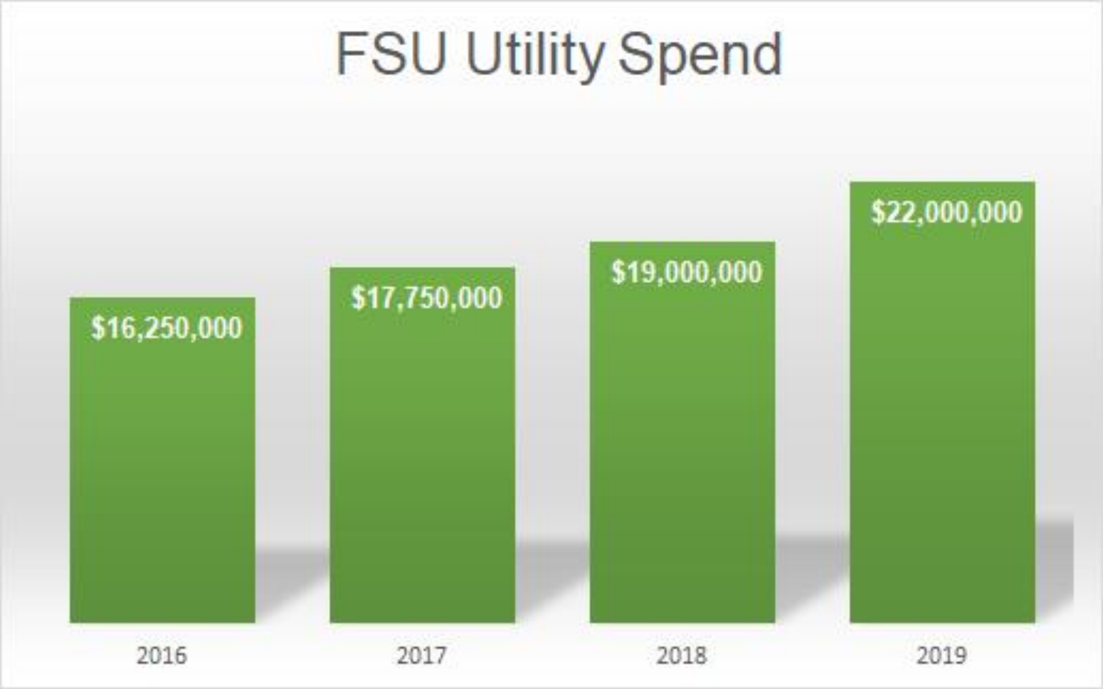
- HVAC accounts for 38% of total campus energy consumption

- The team is focusing on HVAC operations and equipment to achieve our campus demand/consumption reduction goal

  - Total of 21 chillers on campus:
    - CUP: 6 chillers
    - SAT 1: 6 chillers
    - SAT 2: 6 chillers
    - Stadium: 3 chillers

Zargham

FSU's Current Standing



Driving Forces:

- Increase in Student Population
- Increase in Faculty Population
- Increase in Number of Lectures and Labs
- Increase in City Utility Rates
- Climate Change
- Decrease in Equipment Efficiency
- Aging of Buildings and Materials

Zargham

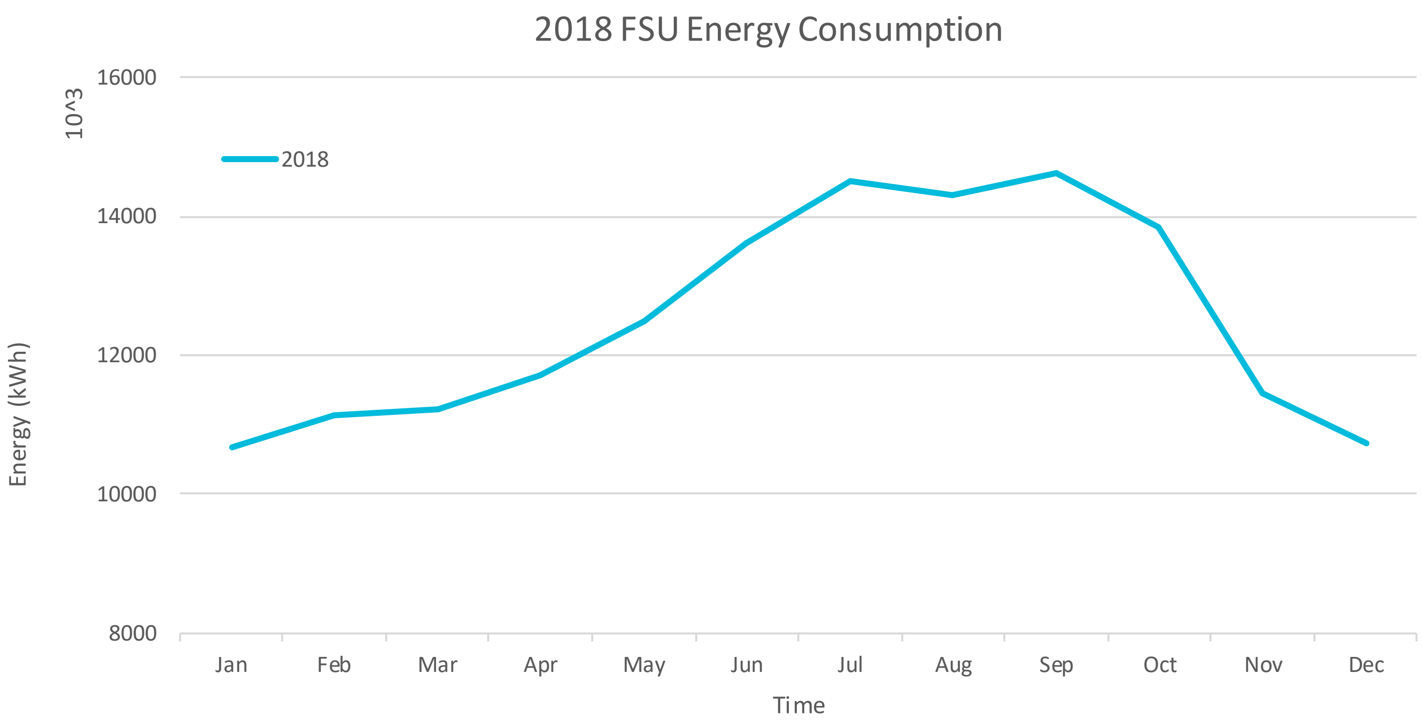
Tallahassee Utility Rate Structure

- Demand Charge ($/kW):
  - Base Charge – 13.46
  - Discount – 1.52
- Energy charge ($/kWh):
  - Base charge – 0.02237
  - Solar – 0.05
  - Fuel – 0.02939
- Power factor adjustment (negligible)

Total Demand Charge ($/kW)	Total Energy Charge ($/kWh)
11.94	0.105

Zargham

Energy Consumption

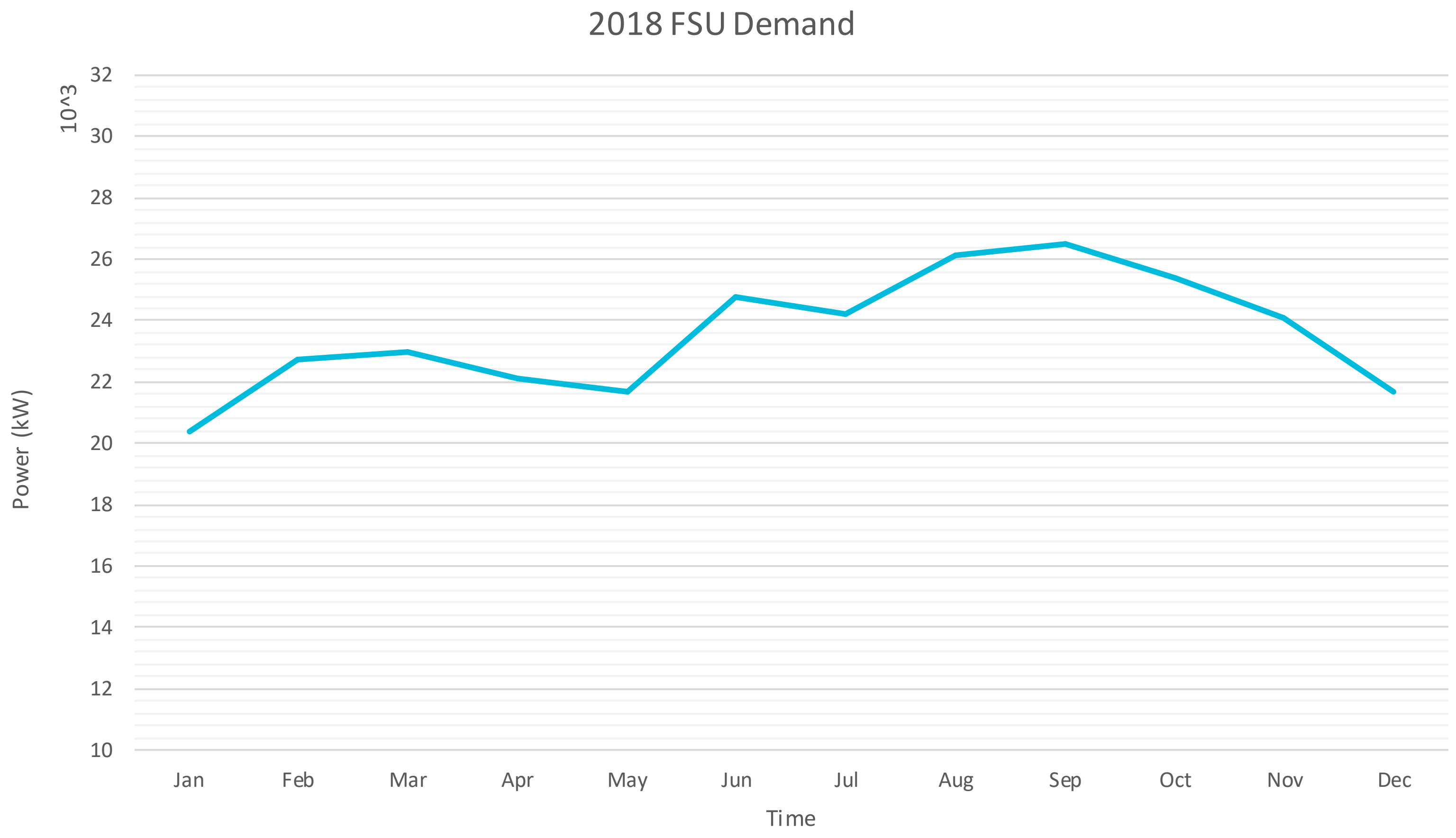


Month	Energy Consumption (kWh)	Cost of Consumption ($)
Jan	10,677,884	1,121,177
Feb	11,140,576	1,169,760
Mar	11,214,102	1,177,480
Apr	11,719,637	1,230,561
May	12,506,359	1,313,167
Jun	13,605,957	1,428,625
Jul	14,507,720	1,523,310
Aug	14,304,363	1,501,958
Sep	14,615,064	1,534,581
Oct	13,853,675	1,454,635
Nov	11,463,273	1,203,643
Dec	10,746,646	1,128,397

Total: $15,787,294

Zargham

Energy Demand

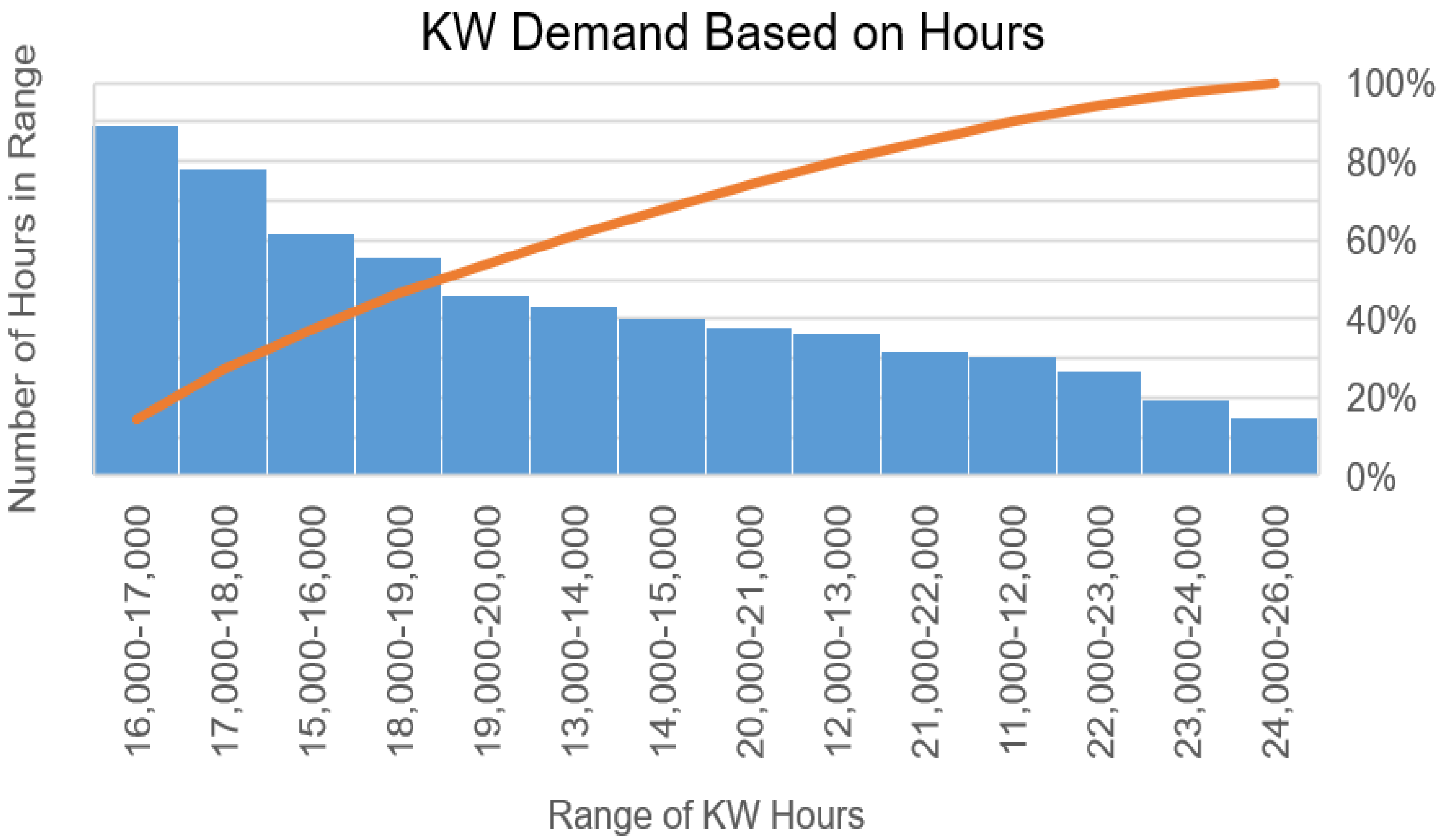


Month	Demand (kW)	Demand Charge ($)
Jan	20,400	243,576
Feb	22,700	271,038
Mar	23,000	274,620
Apr	22,100	263,874
May	21,700	259,098
Jun	24,800	296,112
Jul	24,200	288,948
Aug	26,100	311,634
Sep	26,500	316,410
Oct	25,400	303,276
Nov	24,100	287,754
Dec	21,700	259,098

Total: $3,375,000

Zargham

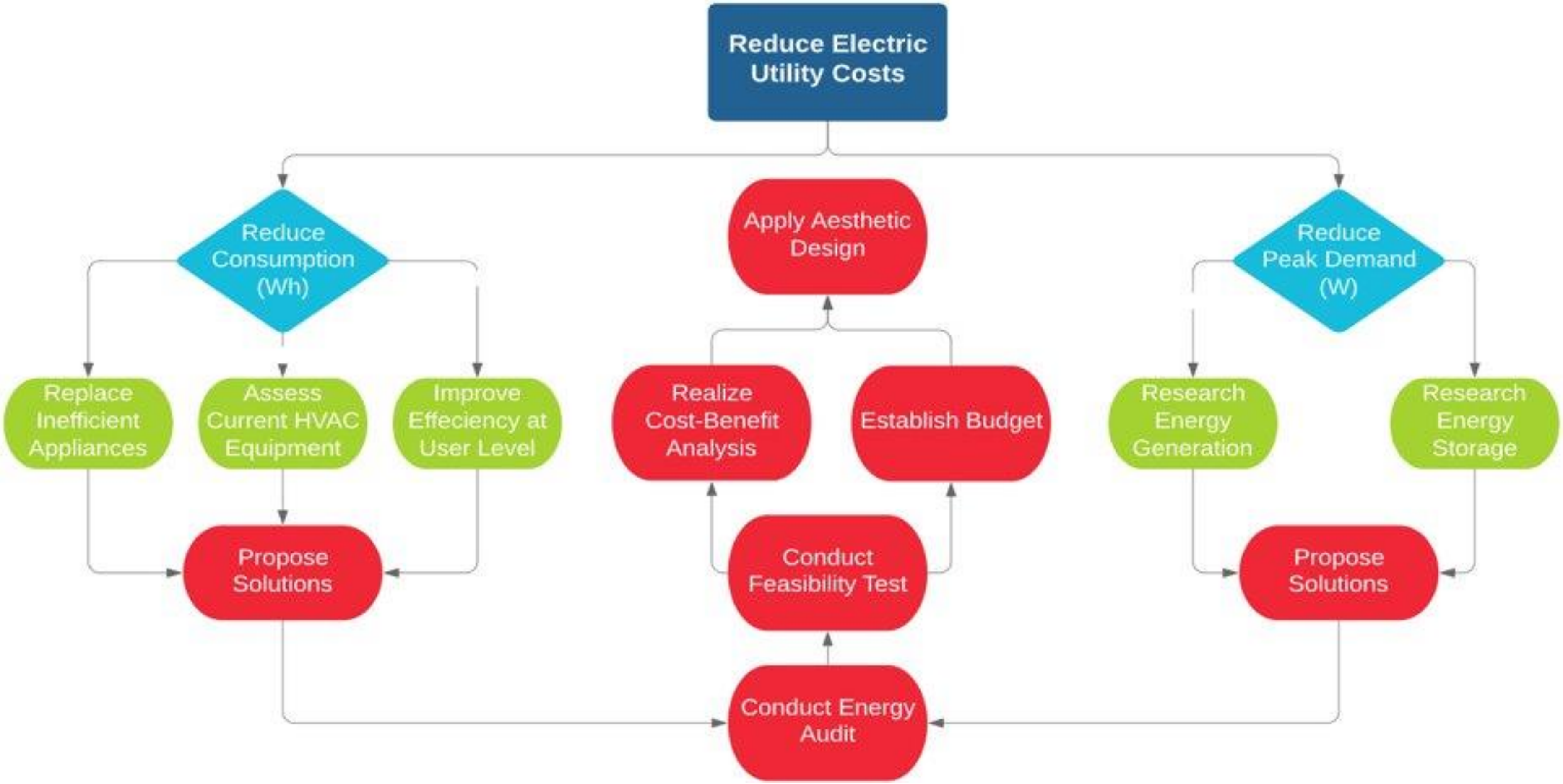
Demand Based on Hours



Demand Range (kW)	Hours in this Range
11,000-12,000	612.8
12,000-13,000	726.9
13,000-14,000	868.9
14,000-15,000	805.5
15,000-16,000	1238.4
16,000-17,000	1782
17,000-18,000	1564.4
18,000-19,000	1111.7
19,000-20,000	917.4
20,000-21,000	754.1
21,000-22,000	637
22,000-23,000	531.7
23,000-24,000	386.8
24,000-26,000	293.3

Meyers

Functional Decomposition



Legend:

- Stage 1
- Stage 2
- Stage 3

Meyers

Concept Selection

Stratified Tanks for Chilled Water Storage

- Stores thermal energy to pump chilled water through HVAC system to alleviate the consumption of energy from HVAC systems.

Large Battery Packs

- Battery packs can be charged during off peak hours to be discharged during peak hours, offsetting FSU's peak demand.

Smart Speed Bumps

- Speed bump design to be implemented around campus that takes advantage of the momentum of the cars to generate energy.

Replace Lightbulbs with LED Lights

Burn Natural Gas to Generate Energy

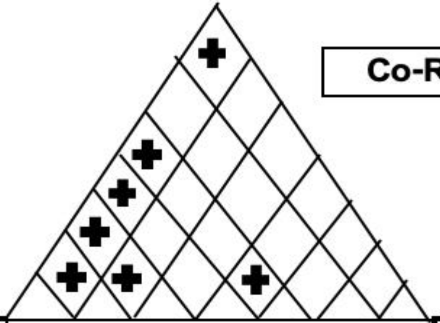
Incentive Programs for Reduced Energy Usage

Collect Rainwater for Irrigation

Build Sunshade to Cover Entire Campus

Meyers

Concept Selection



Technical Requirements / Customer Requirements			IMPORTANCE	Operating Factors: Save $100,000 per month	Reduce peak demand by 7430 KW monthly	Reduce consumption by 950 MWh monthly	Return of Investment must be 7 10 years	10 year Lifetime	Efficiency greater than 90%	Pleases at least 75% of the FSU students, faculty, donors,	Competetive Assesment: Chilled Water Storage Tanks	Battery Storage Systems	Smart speed bump generator
Ergonomic Features	Reduce peak demand	1	5.00	3	9	3	0	0	0	0	G	G	F
	Reduce overall energy consumption	2	3.00	3	3	9	0	0	0	0	G	F	G
	Save money	3	5.00	9	3	3	9	1	1	0	G	G	F
	Durability	4	4.00	1	0	0	1	9	0	0	G	G	F
	Serviceability	5	3.00	1	0	0	1	3	3	0	G	F	F
	Reliability	6	4.00	0	3	3	0	3	9	3	G	G	F
Aesthetic Features	Visually appealing	7	1.00	0	0	0	0	0	0	9	G	G	F
Raw score				76	81	69	52	62	50	21			
Relative %				18%	20%	17%	13%	15%	12%	5%			
Importance Rank				2	1	3	5	4	6	7			

Relationship Key:
- Strong = 9
- Moderate = 3
- Weak = 1
- No Correlation = 0

Co-Relationship Key:
- Positive +
- Negative -

Competetive Assesment key:
- Good = G
- Fair = F
- Poor = P

Pugh, AHP, HoQ Charts

The importance ranking is scaled on a scale from 1-5, with 1 being the least important and 5 being the most important.

Meyers

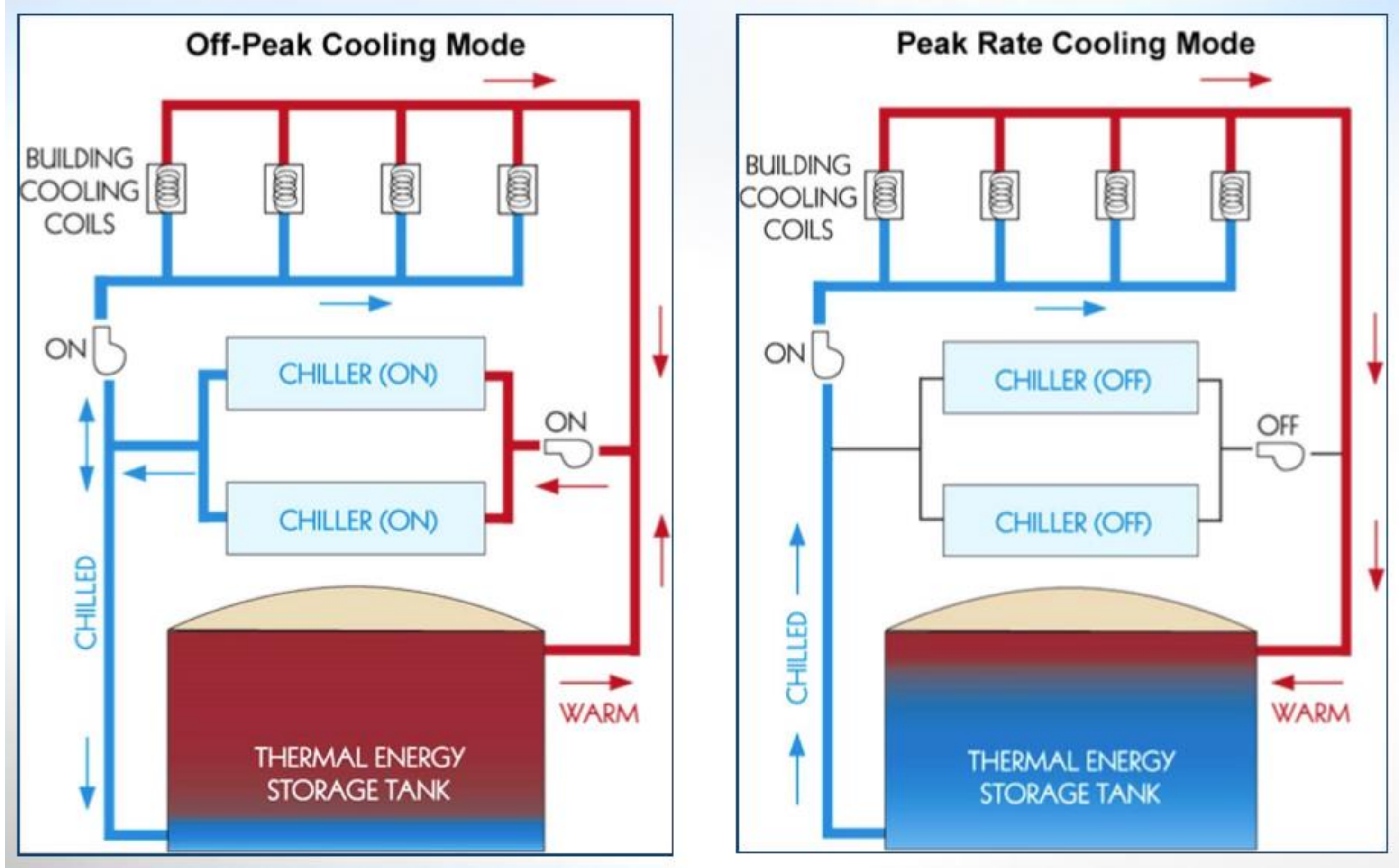
Thermal Storage Tanks

Night

Day

"Charging the Tank"

Chillers are running



"Discharging" the Tank

Chillers not running

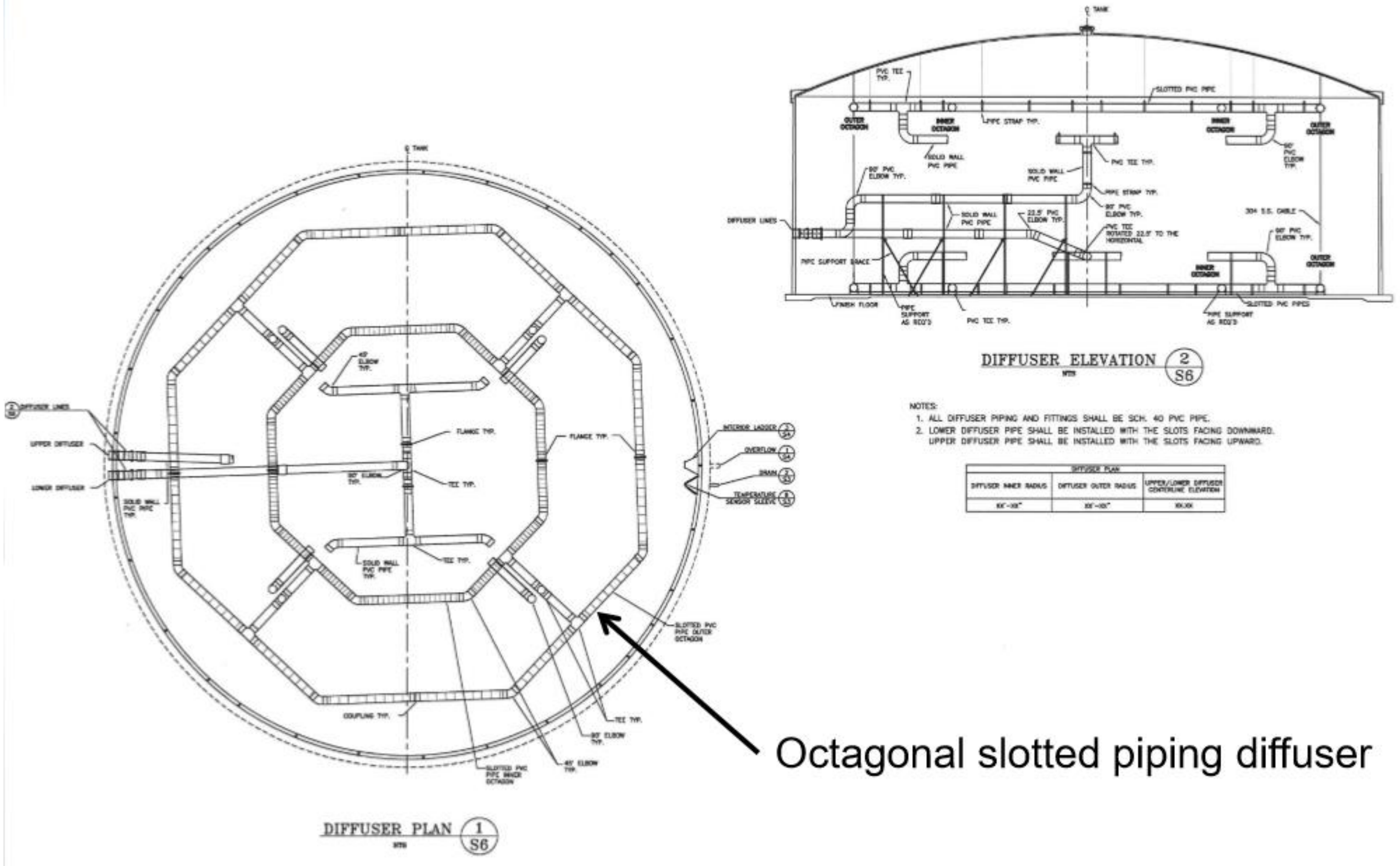
Pumps are running instead

Information courtesy of DN Tanks

Meyers

Thermal Storage Tanks

Energy Storage Technology	Efficiency (%)	Useful Life (Years)	Capital Costs ($/kWh)
Pumped Hydro	80	>25	165
Na-S Batteries	75	14	907
Lead-acid Batteries	72	3	649
Li-ion Batteries	86	10	469
Flywheels	86	>20	11520
Compressed Air	52	25	105
Large CHW TES	93 - 100+	>50	125-300



Information courtesy of DN Tanks

Meyers

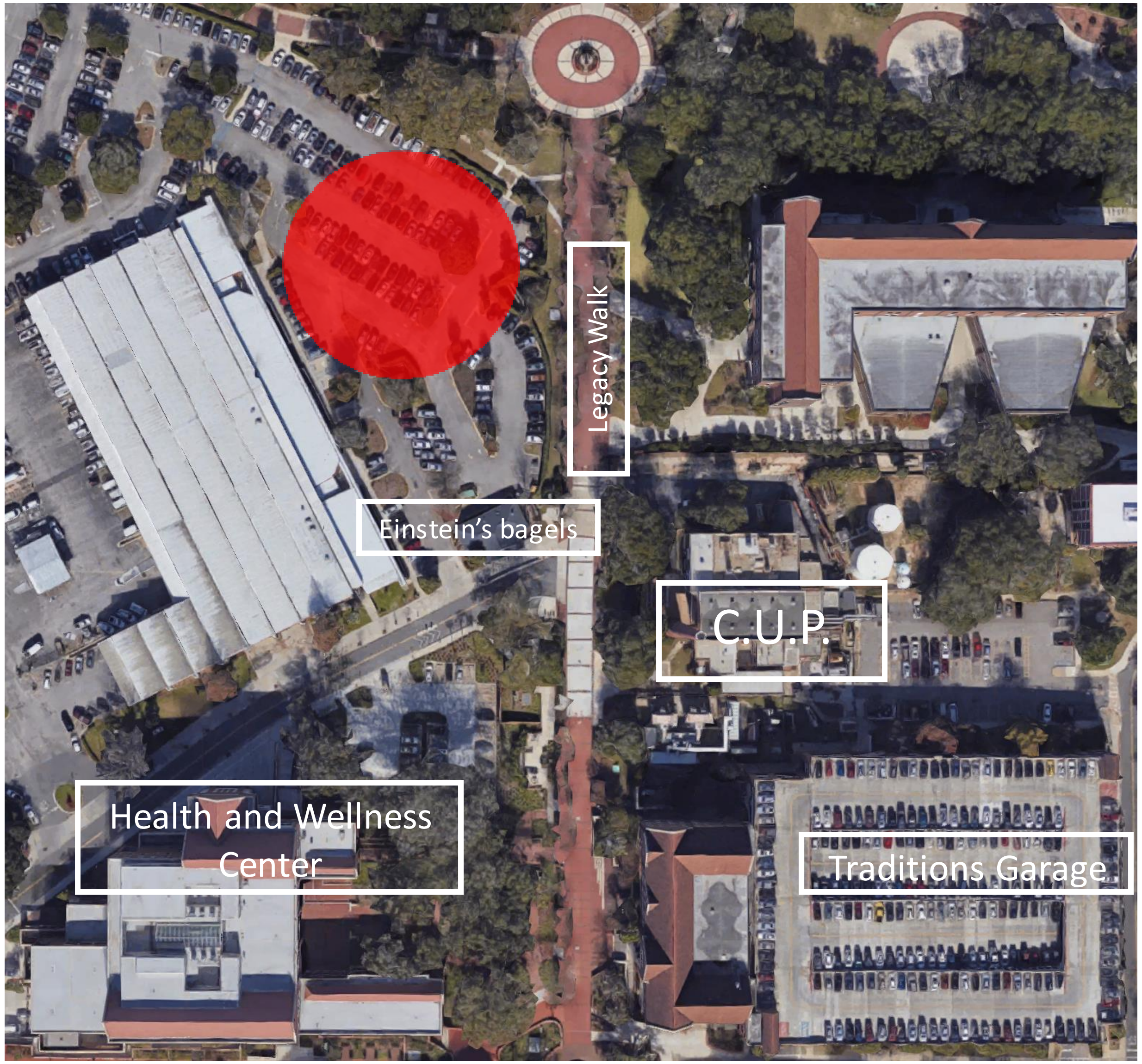
University of Central Florida

- Third largest university in the United States
- 3.0 million-gallon TES tank
- 26,200 ton-hours storage capacity
- Offsets 3,000 kW from peak demand
- Saves over $700,000 annually

Schoengrund

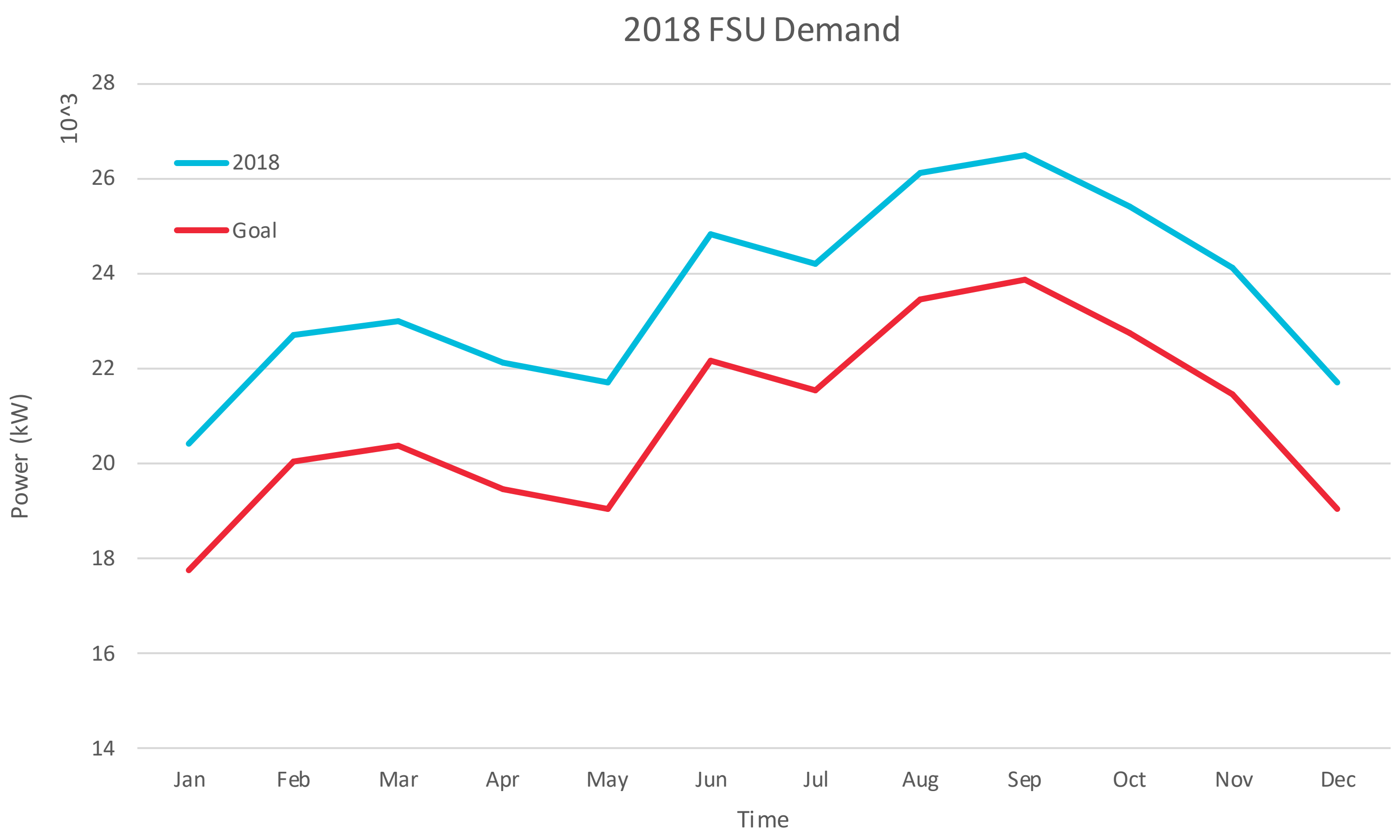
Florida State University

- Fifth largest university in Florida
- No peak electric demand solution in place.
- CUP capacity is similar to UCF
  - 26,500 ton-hour capacity
- Fulfills aesthetically pleasing requirement



Schoengrund

Energy Demand with TES Tank



Month	Demand (kW)	Demand Charge ($)
Jan	17,750	211,935
Feb	20,050	239,397
Mar	20,350	242,979
Apr	19,450	232,233
May	19,050	227,457
Jun	22,150	264,471
Jul	21,550	257,307
Aug	23,450	279,993
Sep	23,850	284,769
Oct	22,750	271,635
Nov	21,450	256,113
Dec	19,050	227,457

Total: $2,995,750

Schoengrund

Concluding Statements

- Demand Reduction Savings at FSU: **$380,000** per year
- Total Project Cost: **$5,700,000**
- ROI (Years): **15 years**
- Useful Life of TES Tank: **>50 years**

The Team's Preliminary Analysis of a TES Tank installation as a solution to offset the CUP to off-peak hours proved to be a feasible investment for FSU.

The Team will continue to work with Trane and DN Tanks to turn our theoretical forecasts into exact numbers that are guaranteed by both companies.

Schoengrund

5 Most Important Points

1. The team selected thermal storage by using a stratified chilled water tank as the solution to the peak electric demand reduction problem at Florida State University.
2. DN Tanks was selected as the vendor for the thermal storage tank.
3. Surrounding universities (UCF) have used this solution for their similar problem.
4. The sponsor and manufacturer will continue to aid the team in sizing, pricing, and implementing the thermal storage solution.
5. UCF saves more than $700,000 annually by offsetting 3,000 kW from their peak electric demand.

Schoengrund

References

Hospital Central Utility Plant: Projects: Burns & McDonnell. (n.d.). Retrieved September 27, 2019, from https://www.burnsmcd.com/projects/hospital-central-utility-plant.

United States (English). (n.d.). Retrieved September 28, 2019, from https://www.trane.com/Index.aspx.

(n.d.). Retrieved September 29, 2019, from https://m.fsu.edu/employee/device/large/maps/map?filter=&_tab=browse&_switchtab=1&feed=main_campus_map_2017&id=main_campus_map_2017/FSU+Main+Campus+Buildings/Central+Utilities+Plant+(CUP)&parentId=main_campus_map_2017/FSU+Main+Campus+Buildings.

US Debt Visualized: Stacked in $100 dollar bills. (n.d.). Retrieved September 29, 2019, from http://demonocracy.info/infographics/usa/us_debt/us_debt.html.

How to define a project scope? (2018, September 14). Retrieved September 29, 2019, from https://bloomcs.com/how-to-define-a-project-scope/.

Gcr, & Gcr. (2018, November 20). GCR Staff. Retrieved September 29, 2019, from http://gcrcloud.io/2018/11/14/how-to-accurately-measure-the-roi-of-unified-communications/.

Schoengrund

Questions?

Team Members:	Email:
Edgardo Cordero	edc15@my.fsu.edu
Steven Decker	sd16b@my.fsu.edu
Alec Schoengrund	abs16d@my.fsu.edu
Mira Meyers	mam15x@my.fsu.edu
Keaton Zargham	ksz17@my.fsu.edu
Juan Villalobos	jjv15b@my.fsu.edu

Schoengrund